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SYSTEMIC RISK DETERMINANTS IN THE EUROPEAN BANKING INDUSTRY
A PANEL DATA ANALYSIS OVER 2006-2012[1]

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Abstract *The recent financial turmoil has stimulated a rich debate in the banking and financial literature on the identification of systemic risk determinants, as well as of devices to forecast and prevent crises. This paper explores the contribution of corporate variables on systemic risk with a CoVaR approach (Adrian and Brunnermeier, 2016). Using a balanced panel database covering 141 European banks belonging to 24 European countries, listed from 2006Q1 to 2012Q4, we investigate the impact of corporate variables over several regimes that characterised the European context in recent years, namely the subprime crisis (2007Q3-2008Q3), the European Great Financial Depression (2008Q4-2010Q2) and the sovereign debt crisis (2010Q3-2012Q4). Our empirical evidence shows that size did not play a significant role in spreading systemic risk, while maturity mismatch did. However, the nature and the intensity of these two determinants vary across the three crises.*

Keywords: Systemic Risk, Banking System, Global Financial Crises, Value at Risk, CoVaR, Panel data.

JEL Classification: G01, G15, G021, C23.

1. INTRODUCTION

Over the period 2006-2012, the European banking system was affected by three different regimes of financial turmoil: the Subprime Crisis, running from the start of the real estate subprime loans crisis in 2007Q3 to 2008Q3 (also identified as "early crisis", see e.g. Kashyap and Zingales, 2010; Kuppuswamy and Villalonga, 2010); the Great Financial Depression, running from 2008Q4 (the bankruptcy of Lehman Brothers) to 2010Q2 (also identified as "late crisis", see e.g. Kashyap and Zingales, 2010; Kuppuswamy and Villalonga, 2010); and the Sovereign Debt Crisis, running from 2010Q3 (in correspondence of emerging news about Greece's default) to 2012Q4 (see e.g. Giordano et al., 2013; Beirne and Fratzscher, 2013).

Following these financial crises, national and international monetary authorities have devoted an increasing attention to the efficacy and stability of the banking system (Reinhart and Rogoff, 2009). This has led to a substantial reconsideration of the role of the supervision system for the banking and financial industries. In Europe, banking supervision authorities focused their attention on measures of micro-prudential regulation, like the different capital requirements of the Basel I, Basel II and then Basel III Agreements[2]. More recently, this approach was extended to a macro-prudential perspective (Borio, 2003).

[2] Basel I Agreement, signed in 1988, obliges banks to keep as reserve the 8% of their loans, without considering the level of risk of loans. To this purpose, Basel II Agreement, published in 2004, has a more complex system of evaluation of credit riskiness, known as the three Basel's pillars based on several banks' features. The break-up of the recent financial crises forced the European monetary authorities (Basel Committee on Banking Supervision) to agree in 2010-2011 the Basel III to improve the quantity and quality of the banking capital and the introduction of two innovative indicators such as the liquidity coverage and the net stable funding ratios.

The challenges of the recent financial crises have pushed financial literature to devote much effort in understanding and describing the different features of systemic risk (Hansen, 2014, Paltalidis et al., 2015) and systemic risk leading factors (Weiss et al., 2014a; Allen et al., 2010), as well as in implementing reliable interventions to overcome this phenomenon (Rodriguez-Moreno and Pena, 2013). Several authors investigate this issue from different perspectives, either related to the connection between bank size and systemic risk (Pais and Stork, 2013) in a cross-country perspective (Slijkerman et al., 2013; Weiss et al., 2014b) or in its connection with financial contagion and financial fragility (Betz et al., 2016; Martinez-Jaramillo et al., 2010). Indeed, a crucial point is the measurement of risk. In addition to the traditional measures, often criticised because mainly limited to balance sheet information (Huang et al., 2009), more recent studies (Acharya et al., 2012; Black et al., 2016) focus on corporate variables related to the maturity mismatch between assets and liabilities.

In this paper, we make use of the *CoVaR* measure of systemic risk proposed by Adrian and Brunnermeier (2016), that consider the role of both market and corporate variables, i.e. size, maturity mismatch and leverage, on systemic risk during the recent crises. Along the line of Black et al. (2016) and Lopez-Espinosa et al. (2012), our analysis covers the European Banking system, as we analyse a sample of 141 European banks continuously listed in the stock markets of 24 European countries, belonging both to the Euro and non-Euro area, from the first quarter of 2006 (2006Q1) to the last quarter of 2012 (2012Q4). As a contribution to former literature, our analysis explores the different phases of the recent financial crises that affected European markets up to 2012, namely the Subprime Crisis, the Great Financial Depression, and the Sovereign Debt Crisis.

Our results challenge a traditional assumption in the analysis of the European system, linking the *"too big to fail"* issue to a higher contribution of large banks to systemic risk factors. In particular, we find that, if we consider the whole sample period, size is likely to act as a shield against systemic risk, rather than boosting the phenomenon. By contrast, other corporate variables and financial ratios (i.e. maturity mismatch, beta, market to book value and market volatility) are more likely to affect systemic risk.

The remainder of the paper is organised as follows. Section 2 describes our methodology and data. Section 3 reports empirical analysis, while Section 4 concludes.

2. METHODOLOGY, DATA AND VARIABLES

Our analysis is performed on the 141 continuously listed banks belonging to 24 different countries over the period from 2006Q1 to 2012Q4, as reported in Table 1, representing roughly 70% of the market capitalization of the European banking system[3].

[3] Given the balanced nature of our sample (i.e. banks non continuously listed have been dropped), the coverage of banking systems is not homogeneous among countries. For example, only one

[INSERT SOMEWHERE HERE TABLE 1]

Our measure of systemic risk is based on the *CoVaR* introduced by Adrian and Brunnermeier (2016). While the Value-at-Risk (*VaR*) of an institution focuses on the risk of an individual entity in isolation, the *CoVaR* , is an indicator of systemic risk, defined as the *VaR* of the financial system as a whole, conditional on some event $C(X_i)$ related to the institution *i*. Therefore, the $CoVaR_q^{system|C(X^i)}$ is defined by the *q-th* quantile of the conditional probability distribution:

$$Prob(X^{system}|C(X^i) \leq (CoVaR_q^{system|C(X_i)}) = q\% \quad (1)$$

where X^i is the market-valued asset return of institution *i*, and X^{system} is the return of the portfolio, computed as the average of the X^i's weighted by the lagged market value assets of the institutions in the portfolio. Adrian and Brunnermeier (2016) measure the contribution of each single institution to systemic risk by the *ΔCoVaR*, namely the difference between *CoVaR* conditional on the institution being in distress and *CoVaR* in the median state of the institution. Formally, the $\Delta CoVaR_q^i$, i.e. the contribution to systemic risk of institution *i* during the *q* quartile, is defined as follows:

$$\Delta CoVaR_q^i = CoVaR_q^i - CoVaR_{50}^i = \hat{\beta}_q^i(VaR_q^i - VaR_{50}^i) \quad (2)$$

where *q* is always set to be 5%, so that $CoVaR^i$ identifies the system losses predicted on the 5% loss of institution *i*, while $\Delta CoVaR^i$ identifies the deterioration in the system losses, when the institution *i* moves from its median state to its 5% worst scenario. As far as the estimation method is concerned, quantile regressions (*q)* are employed to estimate the *VaR*s and *CoVaR*s (see appendix). Table 2 provides summary statistics for the market-valued asset return (*Xi*), for the market portfolio X^{system}, for the *CoVaR* and *ΔCoVaR* of the 141 banks, estimated weekly over the period from 2006Q1-2012Q3.

[INSERT SOMEWHERE HERE TABLE 2]

The main goal of our analysis is to evaluate the correlation between corporate variables and the measure of systemic risk, in order to forecast what are the bank features more likely to increase the contribution to the overall risk. Following Adrian and Brunnermeier (2016) and Lopez Espinosa et al. (2012), we

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bank is included for the following countries: Luxembourg and The Netherlands in the Euro area; Bulgaria, Czech Republic and Hungary in the non-Euro area. Given the choice to study a balanced panel, we decide to not apply any filters to the sample. We check data for robustness and no bias have been revealed. As it is, the sample represents the most part of market capitalization, therefore a very significant sample from a statistical point of view.

make use of the following corporate variables, collected from the quarterly balance sheets of all the European banks included in the sample:

1) $Leverage_{i,t-1}$ is calculated as the total assets (book value) to equity ratio of bank i at quarter *(t-1)*;
2) $MM_{i,t-1}$ is the maturity mismatch, namely the relative level of short term funding, calculated as the ratio between total short term debt minus cash and total liabilities, for bank *i* at quarter *(t-1)*. This ratio is a proxy of the interconnectedness between financial institutions (see also Allen et al., 2010; Acharya and Merrouche, 2012; Lopez-Espinosa et al., 2012);
3) $Size_{i,t-1}$, as the market value of total assets of bank *i* at quarter *(t-1;)*
4) $MBV_{i,t-1}$ is the market to book ratio, namely the ration between market value of equity and book value of equity, for bank *i* at quarter *(t-1)*;
5) ERV_t is the equity return volatility for bank *i* at quarter *(t-1)*, computed from daily equity returns data within each quarter;
6) $Beta_t$ is the equity market beta for bank *i* at quarter *(t-1)*, computed from daily equity returns data within each quarter.

Table 3 reports the summary statistics for these corporate variables. The average leverage of the European banks in the sample suggests that only roughly 6% of banks' assets are financed by equity. This measure represents, in broad terms, a proxy of the Core Tier 1 index[4]. The average size of the bank's total assets is roughly 54 billion of Euro[5]. Market-to-book values exceed 1[6]. We observe a low level of the beta coefficient during the crisis and a limited percentage of a maturity mismatch measure on the total liabilities of the banks.

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[4] The European Banking Authority set in February 2014 the value exceeds the minimum threshold of 5.5% Core Tier 1 as benchmark for times of crisis.

[5] Summary statistics of bank size (market value of total assets) show that average size is larger for Euro countries than for non-Euro countries. Change in size over time show that there was a substantial drop between 2008 and 2009. No relevant decline, by contrast, is evident before 2010.

[6] Descriptive statistics show that the average ratio of market to book value, in several countries, is less than one. This is the case in France (0.47), Italy (0.89) and Ireland (0.93), while the average value is positive for the remaining countries. A general decline in the ratio is observed between 2007-2008 and 2009, i.e. during the period of Great Financial Depression. For instance, the market to book value of Irish banks changed dramatically, dropping from 1.85 in 2007 to 0.62 in 2008 and then to 0.12 in 2009. Both German and Italian banks show similar pattern, with lower intensity. Finally, in Southern Europe, i.e in Greece, Spain and Portugal, there was a relevant decrease in the market to book value since 2010, i.e. in the period of the Sovereign Debt Crisis. We observed a few negative values in the value. We checked for robustness of our results when dropping these cases, and we did not identify any significant impact.

[INSERT SOMEWHERE HERE TABLE 3]

3. EMPIRICAL RESULTS

We estimated panel regression models with fixed effects: the inclusion of fixed effect is based on Hausman tests with statistical significance at less than 1% in all cases. The dependent variable is the $\Delta CoVaR_{it}$, and a full specification can be described as follows:

$$\Delta CoVaR_{it} = \beta_{i0} + \beta_1 \Delta CoVaR_{it-1} + \beta_2 VaR_{it-1} + \\ + \beta_3 Leverage_{it-1} + \beta_4 MM_{it-1} + \beta_5 ERV_{it-1} + Beta_{it-1} \\ + \beta_7 MBV_{it-1} + \beta_8 Size_{it-1} + \\ + [\beta_{c1} Crisis_1 + \beta_{c2} Crisis_2 + \beta_{c3} Crisis_3] \; or [\sum_{k=1}^{m-1} \beta_k Time_k] + \varepsilon_{it} \tag{3}$$

As in the relevant literature (Adrian and Brunnermeier, 2016; Lopez Espinosa et al., 2012), lagged values for VaR and $\Delta CoVaR$ are included in our specification. Besides the six corporate variables, our model also include either a set of time dummies or a set of three dummies identifying the three subperiods in the financial crisis, namely Subprime Crisis, the Great Financial Depression, and the Sovereign Debt Crisis.

Results obtained under different model specifications are reported in Table 4. In column (i), we have the benchmark specification that includes only quarterly corporate variables and quarter time dummies; specification (ii) replaces time dummies with three crisis dummies: Crisis 1, i.e. the subprime crisis (2007Q3-2008Q3), Crisis 2, i.e. the European Great Financial Depression (2008Q4-2010Q2), and Crisis 3, i.e. the sovereign debt crisis (2010Q3-2012Q4). Finally, in specification (iii) we included the interaction of corporate variables with three crisis dummies to capture the potential different effects of corporate variables over the three periods.

[INSERT SOMEWHERE HERE TABLE 4]

In the light that $\Delta CoVaR_{it}$ is negative, all negative coefficients imply an increase in systemic risk, and vice versa. Specification (i) identifies the average effect of corporate variables over 2006-2012, suggesting that only a decrease in equity return volatility significantly affects systemic risk over the whole period. Specification (ii), replacing time dummies with crisis dummies, shows that over the three sub-periods systemic risk has largely increased, with a stronger magnitude during the Great Financial Depression. Comparing models (i) and (ii), we observe that, while most results are qualitatively similar, the estimation fitting is much better when time dummies are included, instead of crises dummies (model i vs model ii).

The results from model (iii) highlight the interactions between corporate variables and the crisis dummies. If we consider the whole period, size is correlated with an increase of systemic risk. Two other corporate variables, i.e. beta coefficient and maturity mismatch, show a statistical significance, but positive coefficient. This result can be interpreted as evidence of a "systemic risk shield" provided by both variables. In particular, maturity mismatch may be a proxy for interconnectedness of the intermediaries of the financial system and thus the sign of the coefficient shows a higher degree of interconnectivity.

If we analyse the interactions between crisis dummies and variables during the subprime crisis period, we find that size is likely to be a "shield" with respect to the spreading off systemic risk during the three crises, although with different magnitudes in the three sub-periods. On the contrary, maturity mismatch[7] plays an important role in increasing the level of systemic risk of European banks between 2007 and 2010, period of the Great Financial Depression. This result implies that a decrease in banks' short term debt may be at a first sight a signal of low risk, being the banks less depending on external potentially unstable market funding. A decrease in short term debt means a substantial reduction of interconnected credit lines and a fear of running out of liquidity for some banks. For this reason, the decrease of the degree of the banking system interconnection represents a clear sign of an increasing of systemic risk, which took place mainly during the Great Financial Depression.

During the Great Financial Depression the beta coefficient has a positive impact on systemic risk. The same occurs for the market to book variable. This financial ratio is often implemented in the corporation evaluation process in order to determine corporation terminal value. If we consider the market to book value, the decrease of the market value may be partially slackened or emphasized by a faster or slower decrease in the book value. From an economic point of view, while a decrease in the market to book value of a corporation relies essentially on the dynamics of state macroeconomic variables, a decrease in the book value may eventually hide its roots in several reasons, ranging from accounting principles to the existence of possible regulation arbitrages. These institutional aspects strictly connected with regulation may be of some relevance in determining an increase of systemic risk.

[7] Short term or unstable liabilities are illiquid assets and may be not a feasible device in the banking activity of transforming risks and maturities. The Economist on the 12th April 2014 in an article entitled "The slumps that shaped modern finance" writes: *"Future risks were to be neutralized by a new legislation, the Glass Steagall rules that separated stock market operations from more mundane lending and gave the Fed new powers to regulate banks whose customers use credit for investment."*

6. CONCLUSIONS

In this paper we provided robust empirical evidence on the role of banks' corporate determinants to the overall systemic risk in the European financial system over a period of time comprising the recent financial crises. We implemented the CoVaR methodology of Adrian and Brunnermeier (2016) on a sample of 141 European banks continuously listed over the period 2006Q1- 2012Q4 with new model specifications including the interaction of corporate variables with three crisis dummies, allowing us to capture the different effect of the corporate variables over the three periods.

We showed that maturity mismatch played a relevant role for systemic risk. Interconnectivity among financial institutions turns out to be a useful device for diversifying risk during the whole period and it increases systemic risk during the financial crisis.

We provided further evidence in support of the "too big to fail" idea. During the whole period banks' size is likely to increase systemic risk, while in the three sub-periods, size turns out to be a sort of "insurance" against bankruptcy. These findings are complementary to what reported in Pais and Stork (2013), with specific reference to the case of crisis. In addition, we offer a more insightful picture than Lopez Espinosa et al (2012), we use a larger number of European bank and we analyse the effects of corporate variables during the three crisis sub-periods experienced in Europe. Size did not contribute to spread systemic risk neither in the Subprime Crisis, neither in the Sovereign Debt Crisis, while a marginal contribution to systemic risk occurs during the Great Financial Depression. On the contrary, maturity mismatch contributed to systemic risk in the period between 2007 and 2010. Market to book value and beta coefficient did provide a marginal contribution to systemic risk during the Great Financial Depression.

The findings in this paper suggest several developments. It will be important to extend the *CoVaR* analysis to a wider range of European banks using a larger but unbalanced data set; a larger number of banks per country may allow to identify the behaviour of different business models of banks toward systemic risk in financial turmoil. An alternative line of research is to employ the framework on systemic risk and banks to explore the role of the shadow banking (see for instance Bellavite Pellegrini et al., 2017). We leave this to future research.

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TABLE 1. COUNTRIES REPRESENTED IN THE SAMPLE

The Table classifies all banks included in our sample according to their nationality. The sample covers all the 24 countries in the European Union with at least one bank listed over the full period 2006Q1-2012Q4: 15 countries belong to the Euro zone, and 9 are out of the Euro zone.

Euro area		Non-Euro area	
Country	N. of banks	Country	N. of banks
Austria	7	Bulgaria	1
Belgium	3	Czech Republic	1
Cyprus	4	Denmark	25
Finland	2	Hungary	1
France	18	Lithuania	2
Germany	7	Poland	13
Greece	7	Romania	2
Ireland	2	Sweden	4
Italy	18	UK	6
Luxembourg	1		
Malta	4		
Netherlands	1		
Portugal	3		
Slovakia	2		
Spain	7		
Total	86	Total	55

TABLE 2. SUMMARY STATISTICS FOR XI, VAR, COVAR, ΔCOVAR

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, for the market equity losses X^i and the 95%-risk measures, calculated for the 141 financial firms on weekly data from 2006Q1-2012Q4. The individual firm risk measures, *VaR*, are obtained by running 95%-quantile regressions of returns on the one-week lag of the market variables and by computing the predicted value of the regression. *CoVaR* is the predicted value from a 95%-quantile regression of the financial system equity losses on the institution equity losses and on the lagged market variables. Δ*CoVaR* is the difference between *CoVaR* calculated from a 95%-quantile regression and the *CoVaR* calculated from a 50%-quantile regression. Source: Datastream.

	Obs.	Mean	Median	Min	Max	Std. Dev
X^i	3,948	0.002	0.000	-0.398	0.655	0.054
VaR	3,948	-0.090	-0.076	-0.586	0.000	0.056
CoVaR	3,948	-0.052	-0.045	-0.202	-0.011	0.024
ΔCoVaR	3,948	-0.036	-0.033	-0.147	-0.006	0.016

TABLE 3. SUMMARY STATISTICS FOR CORPORATE VARIABLES

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, of the corporate variables of the European banks in our sample, calculated over the full period 2006Q1-2012Q4. Leverage is defined as the ratio between the total assets and the book value of total equity (average value); maturity mismatch is calculated as the total short term debt minus cash to total liabilities ratio; equity return volatility is calculated as the standard deviation of the daily equity returns of each banks in the sample; beta is the equity market beta and is calculated as the ratio between the covariance of the equity security on the market and the variance in the market; market to book value is calculated as the ratio between market and book value of each bank; size represents the total assets of the banks, in millions of Euro (average value calculated over the full sample 2006-2012). Source: Datastream.

Variable	Obs.	Mean	Median	Min	Max	Std. Dev
Leverage	3,226	16.860	13.848	1.180	87.534	35.730
Maturity Mismatch (%)	2,945	13.730	11.996	-118.033	78.617	15.031
Equity return volatility	3,872	0.020	0.019	0.000	0.198	0.020
Beta	3,872	0.760	0.723	-0.968	3.948	0.690
Market to book value	3,268	1.170	0.949	-6.454	5.289	1.240
Size (mn €)	2,899	54,556	7,022	0,219	940,351	110,598

TABLE 4. REGRESSION RESULTS. CORPORATE VARIABLES AND MARGINAL EFFECT DURING THE SUB-PERIODS.

The table reports regressions using alternative model specifications. Model (i) is the benchmark specification using corporate variables and time dummies. Model (ii) incudes corporate variables, and replaces time dummies with a set of crisis dummies. Model (iii) includes corporate variables, time dummies and the interaction of corporate variables with the three crisis dummies. *, **, *** denote the 1%, 5% and 10% significance level, respectively. Sample period: 2006Q1-2012Q4.

	(i)	(ii)	(iii)			
			Baseline coefficients	Marginal effects over Crisis 1	Marginal effects over Crisis 2	Marginal effects over Crisis 3
ΔCoVaR(-1)	0.490***	0.228***	0.379***	0.052	0.072	0.131***
	(0.020)	(0.020)	(0.056)	(0.042)	(0.044)	(0.043)
VaR(-1)	0.007*	0.011	0.024**	-0.007	-0.015	-0.005
	(0.004)	(0.008)	(0.011)	(0.009)	(0.010)	(0.010)
Leverage(-1)	0.000	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MM(-1)	0.001	-0.027	0.019*	-0.027**	-0.052**	-0.019
	(0.012)	(0.023)	(0.011)	(0.011)	(0.023)	(0.013)
ERV(-1)	-0.290**	-0.041	-0.102	-0.227	-0.018	-0.196
	(0.115)	(0.148)	(0.248)	(0.274)	(0.278)	(0.273)
Beta(-1)	0.004	0.003	0.010**	-0.007	-0.017**	-0.005
	(0.003)	(0.005)	(0.004)	(0.006)	(0.007)	(0.005)
MBV(-1)	0.000	-0.003	0.001	-0.003	-0.006*	-0.001
	(0.000)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)
Size(-1)	-0.003	-0.003	-0.007***	0.007***	0.008***	0.003**
	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.001)
Crisis 1		-0.093***	-0.159***			
		(0.003)	(0.037)			
Crisis 2		-0.121***	-0.076			
		(0.005)	(0.055)			
Crisis 3		-0.077***	0.018			
		(0.004)	(0.039)			
Fixed Effects	Yes	Yes	Yes			

Time D. (28 q.)	Yes	No	No	
Constant	-0.219***	-0.213***	-0.190***	
	(0.032)	(0.068)	(0.043)	
Observations	3,948	3,948		3,948
R-squared	0.870	0.252		0.874
AIC	-12494	-6138		-12545
BIC	-12283	-6069		-12185

APPENDIX. COVAR ESTIMATION

The CoVar definition introduced by Adrian and Brunnermeier (2016) relates to the concept of Value-at-Risk (VaR) according to the following:

$$Prob(X^i \leq VaR_q^i) = q\% \qquad \text{(A.1)}$$

$$Prob(X^{system}|C(X^i) \leq (CoVaR_q^{system|C(X_i)}) = q\% \qquad \text{(A.2)}$$

Estimations of VaR and $CoVaR$ are obtained by quantile regressions. First, one can estimate the predicted value of a quantile regression where the financial sector losses $X_q^{system|X^i}$ is determined given the losses of a particular institution *i* for the q%-quantile:

$$\hat{X}_q^{system|X^i} = \hat{\alpha}_q^i + \hat{\beta}_q^i X^i \qquad \text{(A.3)}$$

where $\hat{X}_q^{system|X^i}$ denotes the predicted value for a particular q%-quantile of the system conditional on a return realization X^i of institution *i*. From the definition of VaR, in equation (1), we have that:

$$VaR_q^{system|X^i} = \hat{X}_q^{system|X^i} \qquad \text{(A.4)}$$

In practice, the predicted value from the quantile regression of the system losses on institution *i* losses gives the value at risk of the financial system conditional on X^i, because the $VaR_q^{system|X^i}$ is simply the conditional quantile. Using the particular predicted value of $X^i = VaR_q^i$ yields the $CoVaR_q^i$ measure. More formally, within the quantile regression framework, the $CoVaR_q^i$ measure is as follows

$$CoVaR_q^i = VaR_q^{system|X^i=VaR_q^i} = \hat{\alpha}_q^i + \hat{\beta}_q^i VaR_q^i \quad (A.5)$$

The $\Delta CoVaR_q^i$ is therefore given by:

$$\Delta CoVaR_q^i = CoVaR_q^i - CoVaR_{50}^i = \hat{\beta}_q^i (VaR_q^i - VaR_{50}^i) \quad (A.6)$$

In the estimation, we include a set of state variables to capture the time variation in conditional moments of asset returns. With references to these specific market's factors, according to Lopez-Espinosa et al. (2012), we consider the peculiarities of the European institutional environment and use the following variables:

a) the weekly price of the FTSE Stock Market volatility index $(FTSEVol_t)$;
b) the liquidity spread $(LiqSpread_t)$ calculated as the difference between the three months UK repo rate and the three months UK T bill;
c) the change in French T-bill secondary market 3-month rate (Lopez-Espinosa et al. (2012) $(\Delta Tbill_t)$;
d) the change in slope of the yield curve represented by French 5-year minus three-months interest rate on government bonds $(\Delta Slope_t)$;
e) the change in credit spread, represented by the difference between Baa seasoned Moody's corporate bonds and the 10-year German government bonds $(\Delta CredSpread_t)$;
f) the weekly equity returns from the FTSE European Stock Market Index $(FTSE\,\mathrm{Re}turns_t)$.